ENGINEERING DYNAMICS COMPANY

Damage Studio

HVE Human Vehicle Environment

Markdown Edition — revised to describe the current version of the software

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HVE DamageStudio

Section Twelve of the HVE User's Manual — Version 8

Updated Markdown edition, converted from the legacy manual and revised to match the behavior of the current HVE release.

DamageStudio is a graphical analysis tool that allows vehicle crash safety engineers to visualize collision data, and to correlate collision damage with the kinetics (force magnitude and direction), delta-V, acceleration and other important collision parameters. DamageStudio is a component in the HVE Playback Editor.

DamageStudio may be used to study all types of collisions (e.g., barrier, single vehicle, multi-vehicle, secondary impact, rollover, ...) for all types of vehicles (e.g., passenger car, van, truck, trailer, dolly, ...).

There are many uses for the kind of detailed collision information produced by DamageStudio. One example is the ability to directly compare simulated crush dimensions with a measured damage profile. This kind of analysis may also be used to fine-tune stiffness coefficients from staged collision data.

DamageStudio can also be used to identify the magnitude and direction of individual impulses, peak collision forces and delta-Vs for vehicles undergoing multiple impacts, even if the impacts are simultaneous.

General Procedure

To use DamageStudio, perform the following steps:

1. Set up and execute a collision event.
2. Go to the Playback Editor.
3. Add a DamageStudio report. The DamageStudio window is displayed. *Simulated* damage is the current Viewer option *(updated: the current viewer dropdown uses the short name "Simulated" for the option the original manual called "Geometry, Simulated Damage").*
4. Use the Playback Controller to play the event.
5. Watch DamageStudio's viewer as it displays the damage profile for the first vehicle. Note that the damage profile changes as the simulation progresses. If the event includes more than one impulse, each damage profile is displayed in sequence for each individual impulse.
6. Observe the Damage Profile numeric results (Impulse No., CDC, PDOF and damage profile dimensions) as the simulation progresses. The impulse number is initially *Auto*, and displays the individual impulse number and associated damage profile data as the event progresses.
7. Click on the Impulse Number dropdown list and choose an impulse number. The damage profile data for the selected impulse is displayed.
8. Click *Prev* or *Next* to switch vehicles.
9. Repeat the above steps for each vehicle in the simulation.
10. Change the current Viewer option to *User-entered* damage.
11. Enter a CDC, followed by `<Enter>` or *Apply*. The default damage profile for the CDC is displayed in the Damage Profile group and the associated damage profile is displayed in the viewer.

12. Edit the damage profile data (width, offset, elevation, crush table) and observe the changes to the vehicle damage profile in the viewer.

Overview of Section Twelve

This section describes the background and use of DamageStudio.

- Chapter 32 provides a description of the DamageStudio user interface and the process of using DamageStudio.
- Chapter 33 provides several tutorials showing the user how to accomplish various tasks using DamageStudio. *(Chapter 33 is not included in this edition.)*

Contents

- 32 (part 1) — The DamageStudio Interface
- 32 (part 2) — Using DamageStudio

Related Pages

- Damage Data dialog — the Event Editor dialog used to assign a user-measured damage profile (CDC, PDOF, crush depths, stiffness) to a vehicle. The *User-entered* damage view in DamageStudio is closely related to this dialog.

Chapter 32 — The DamageStudio Interface

Overview

DamageStudio is a graphical analysis tool that allows vehicle crash safety engineers to visualize collision data, and to correlate collision damage with the kinetics (force magnitude and direction), delta-V, acceleration and other important collision parameters. DamageStudio is a component in the HVE Playback Editor.

DamageStudio may be used to study all types of collisions (e.g., barrier, single vehicle, multi-vehicle, secondary impact, rollover, ...) for all types of vehicles (e.g., passenger car, van, truck, trailer, dolly, ...).

DamageStudio provides the following information about a collision:

- Numeric and visual damage profile results for up to 10 individual impulses (collisions) per vehicle
- Collision Deformation Classification (CDC)
- PDOF azimuth (horizontal) and zenith (vertical) angles
- Damage width and horizontal offset
- Damage height and vertical offset
- Crush table (crush depth, free space and total crush) for up to 10 points along the damage width and up to 5 elevations along the damage height
- Crush vectors (color-coded arrows) that illustrate crush depth, free space and total crush
- Damage profile visualization of the damage profile, along with a vector (arrow) that illustrates the PDOF and a sphere that illustrates the impulse center location

(These limits are fixed: 10 collision pulses (impulses) per vehicle, 10 crush depths along the damage width, and 5 crush elevations along the damage height.)

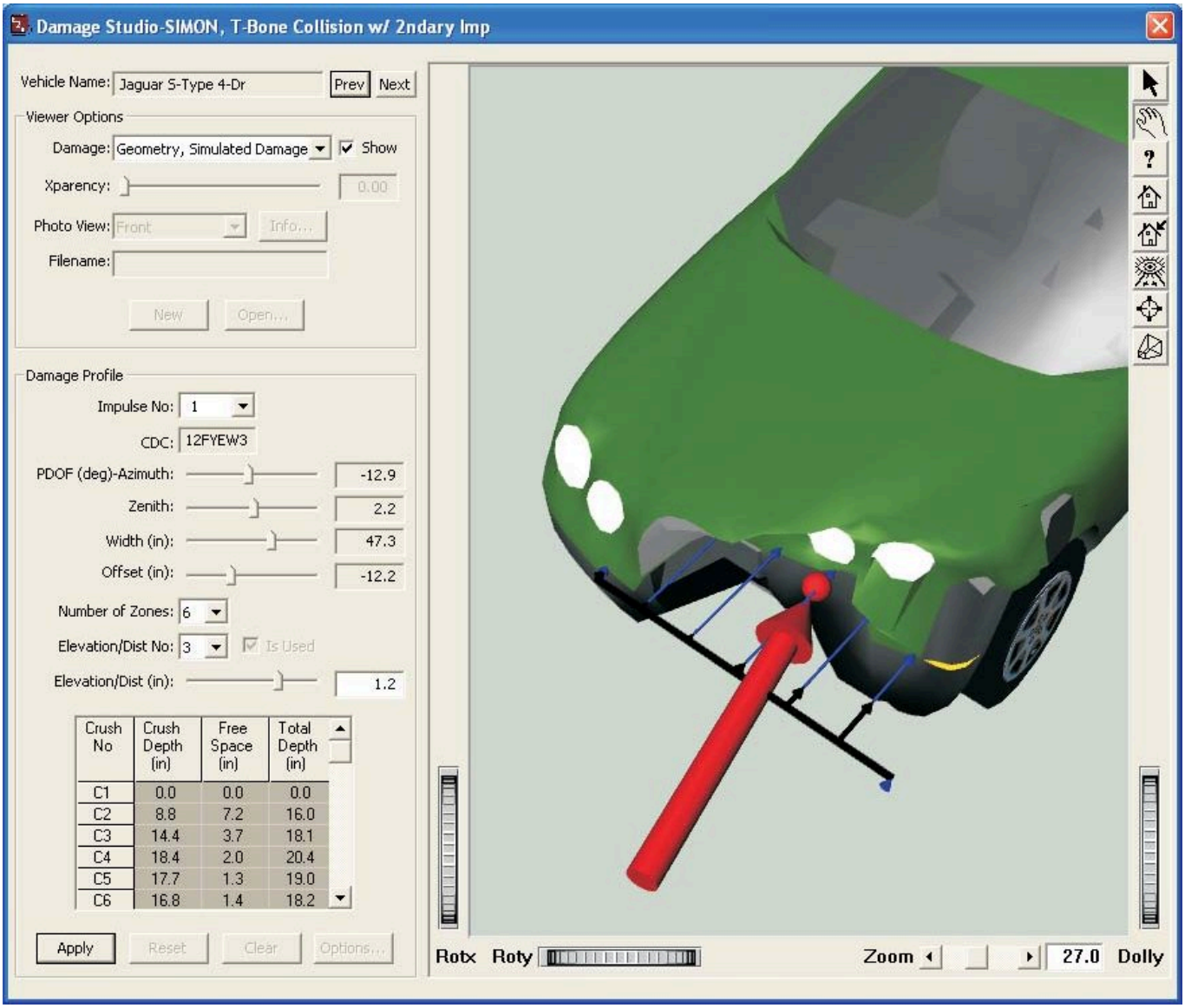


Figure 32-1: Typical DamageStudio window.

A typical DamageStudio window is displayed in Figure 32-1.

> **NOTE:** Much of the numeric data displayed by DamageStudio may also be found in tabular form in the Damage Data output report.

The DamageStudio window includes a 3-D viewer and two groups of supporting information:

- Viewer Options
- Damage Profile

These two features differentiate DamageStudio from the HVE Damage Profiles output report window.

The window also includes a *Vehicle Name* field with *Prev* and *Next* buttons for switching between the vehicles in the event, and a row of buttons below the Damage Profile group: *Apply*, *Reset*, *Clear* and *Options... (updated: the Reset, Clear and Options... buttons are additions since the original manual; Options... opens the DamageStudio Options dialog described later in this chapter)*.

Viewer Options

The Viewer Options group determines what is displayed in the 3-D viewer. Four viewer (damage display) options are available; a fifth, Damage Photograph, is described in the original manual but cannot be selected in the current release:

Original manual name	Current dropdown name	Status
Geometry, Simulated Damage	*Simulated*	Available (simulation events only)
Geometry, Undamaged	*None*	Available
Geometry, From File	*From File*	Available
Damage Photograph	*Photograph(s)*	**Not available.** The entry is not present in the dropdown and the view cannot be selected
Damage, User-entered	*User-entered*	Available

(updated: the current Damage dropdown uses the short names shown in the middle column — the list describes the source of the damage shown for the vehicle geometry. "Simulated" is only offered for simulation events. The "Photograph(s)" entry is no longer present in the dropdown.)

The current Viewer Option is selected from the *Damage* dropdown list. The view is activated by clicking the *Show* checkbox. Clicking *Show* for more than one viewer option causes the selected views to be super-imposed (see Multiple Views, later in this chapter) for purposes of comparison.

A *Transparency* slider and edit field (labeled *Xparency* or *Trans*) is provided so each view can be made partially transparent (0.0 = opaque, 1.0 = fully transparent). This is particularly useful when super-imposing several views.

Geometry, Simulated Damage ("Simulated")

When the

Simulated

damage viewer option is selected, the 3-D viewer displays the vehicle damage calculated by the simulation. It is similar to the Damage Profiles output report window found in the Playback Editor. As the simulation is played, the damage profile dynamically updates, showing the current damage profile. Unlike the Damage Profiles window, DamageStudio also displays the PDOF, impulse center and color-coded crush vectors showing crush depth, free space and total crush depth.

Damage Profile

The Damage Profile group is enabled when the viewer option is

Simulated

. The Damage Profile group displays the current impulse number (up to 10 individual impulses per vehicle may be displayed), along with the following results for the current impulse:

- **Collision Deformation Classification (CDC)** — This is a full implementation of SAE J224B. The first two characters are the clock direction of the PDOF; the 3rd character is the major contact surface (Front, Right, Back, Left, Top, Undercarriage); the 4th character is the specific location of damage on the major surface defined by the 3rd character; the 5th character is the damage elevation (for Front, Right, Back and Left damage) or damage width along the vehicle-fixed x axis (for Top and Undercarriage damage); the 6th character is the type of damage (Wide,

Narrow, Sideswipe, Corner); the 7th character defines the maximum extent (depth) of crush. Refer to Appendix V of the HVE User's Manual for more information on SAE J224B. See also the Damage Data dialog, which uses the CDC to assign default user-entered damage profiles in the Event Editor.

- **PDOF** — By definition, the PDOF is the direction of the impulse (and, therefore, the delta-V). Because HVE is 3-dimensional, the PDOF has both an azimuth angle (the traditional PDOF in the vehicle's x-y plane) and a zenith angle (the vertical component of the PDOF).
- **Width (in)** — For side and end damage, this is the horizontal width of damage. For top and undercarriage damage, this is the width of damage in the y-direction.
- **Offset (in)** — For side and end damage, this is the horizontal distance from the CG to the center of the damage width. For top and undercarriage damage, this is the lateral distance from the CG to the center of the damage width.
- **Number of Zones** — Dropdown list selecting the number of crush zones (1 to 9) across the damage width; the number of crush measurements is the number of zones + 1 (up to 10).
- **Elevation/Distance** — For side and end damage, this is the vertical elevation at up to five locations (above/below the CG) for the crush depths displayed in the crush table. For top and undercarriage damage, this is the x-distance from the CG at up to five locations for the crush depths displayed in the crush table. The *Elevation/Dist No* dropdown selects which of the five elevations is displayed, and the *Elevation/Dist* field displays (and, for user-entered damage, edits) its value.
- **Crush Table** — These are the actual crush depth for physically observable damage, the free space and the total crush depth (sum of actual crush depth and free space). The table columns are *Crush No*, *Crush Depth*, *Free Space* and *Total Depth*. Up to 10 crush depths may be displayed (five is the default).

The 3-D viewer displays the current impulse center and PDOF vector, as well as a set of color-coded arrows (vectors) that illustrate the crush depth, free space and total crush depth for each selected elevation/distance.

Damage, User-entered ("User-entered")

When the *User-entered* damage viewer option is selected, the 3-D viewer initially displays the original (undamaged) vehicle geometry. This option is similar to the Setup, Damage Profiles dialog found in the Event Editor (see the Damage Data dialog page). There is no time domain information available when using this option. The user simply enters and edits one or more damage profiles and observes the results in the 3-D viewer. This process is described in Using DamageStudio.

Damage Profile

The Damage Profile group is enabled when the viewer option is *User-entered*. The Damage Profile group displays the current impulse number (up to 10 individual impulses per vehicle may be displayed), and the CDC field for the current impulse, initially *None*. Upon entering a valid CDC, the damage profile information associated with the CDC (i.e., the PDOF, damage width, etc.) are calculated and displayed (refer to the previous Damage Profile section for a complete description of each field). These values may then be edited.

The 3-D viewer displays the damaged vehicle and its current impulse center and PDOF vector, and color-coded arrows (vectors) that illustrate the crush depth and free space for each selected elevation/distance.

Geometry, Undamaged ("None")

When the

None

(undamaged geometry) viewer option is selected, the 3-D viewer displays the original (undamaged) vehicle geometry. This view may be used for comparison with the simulated vehicle damage.

(updated: the original manual listed this option as "Not implemented"; it is implemented in the current release, including per-view transparency for overlay comparison.)

Damage Profile

The Damage Profile group is disabled when the viewer option is *None*.

Geometry, From File ("From File")

When the *From File* viewer option is selected, the 3-D viewer displays a user-supplied vehicle geometry file (selected with the *Filename* field and *Open...* button). This file may show a damaged vehicle or undamaged vehicle. This view may be used for comparison with the simulated vehicle damage.

(updated: the original manual listed this option as "Not implemented"; it is implemented in the current release, which reads the named geometry file into the viewer scene.)

Damage Profile

The Damage Profile group is disabled when the viewer option is *From File*.

Damage Photograph ("Photograph(s)")

> **NOTE:** This viewer option is **not available**. *Photograph(s)* is not offered in the Damage dropdown, so the view described below cannot be selected. The description is retained because the original manual documents the feature.

As described in the original manual, the *Photograph(s)* option displayed one or more user-supplied vehicle photographs in the 3-D viewer, up to seven per vehicle. A dropdown list suggested the views Front, Right, Back, Left, Top, Undercarriage and Oblique — suggestions only, with the actual views up to the user — and each view had a text box, reached through an *Info...* button, for descriptive information such as camera position and focal length. The intended use was comparison against the simulated vehicle damage.

Multiple Views

Each viewer option includes a *Show* checkbox. By clicking *Show* for more than one viewer option, views from different viewer options may be super-imposed. For example, the undamaged geometry may be super-imposed over the *Simulated* damage view or *User-entered* damage view. The purpose of this capability is to compare the various views and confirm the damage profile results. The per-view *Transparency* control is useful for making the overlaid views readable.

DamageStudio Options

(updated: this dialog is an addition since the original manual.)

Clicking the

Options...
button displays the DamageStudio Options dialog, which controls the graphic annotations drawn in the 3-D viewer:

- **PDOF/Forces** — Radio buttons selecting what force information is shown: *None*, *Current Force* or *PDOF/Impulse Center*. In the current release only *PDOF/Impulse Center* is enabled. A *Color...* button (currently disabled) is provided for selecting the vector color.
- **Crush Vectors** — Radio buttons selecting which crush vectors are shown: *None*, *Current Elevation* or *All Elevations*. In the current release only *All Elevations* is enabled. A *Color...* button (currently disabled) is provided for selecting the vector color.
- **Select Key Results** — A multiple-selection list of result variables. Each selected variable is displayed as a text annotation in the 3-D viewer (updated as the event plays), so key numeric results can be read directly off the DamageStudio display.

For simulation events, the available key results are: Time; Impulse No; Total, Longitudinal, Side and Normal velocity; Delta-V (total, x, y, z); Damage Energy; Total, Forward, Lateral and Tangential acceleration; Impulse (magnitude); Impulse Center x, y, z; PDOF Azimuth and Zenith; Impact force (total, Fx, Fy, Fz); Impact moments (Mx, My, Mz); CDC; Damage Width; Width Offset; Damage Height; Height Offset; and Max Crush. For reconstruction events, a similar (per-impulse rather than time-based) subset is available.

CollisionData

The backbone of DamageStudio is a group of calculated parameters, collectively referred to as CollisionData. CollisionData are calculated at each integration timestep during the simulation. The CollisionData include the following parameters for each colliding vehicle:

- **Impulse Number** — Sequential index used to track individual pulses
- **Other Vehicle** — The ID for the vehicle sharing the pulse
- **Damaged Vertices** — The vertex IDs for the current pulse, and associated with contact with the Other Vehicle
- **Peak Acceleration** — The highest total acceleration for the pulse
- **Peak Force** — The highest force for the pulse
- **Pulse Times (Start, End, Duration)** — Simulation time at which the collision begins and ends, and the difference. The start and end are determined by the time interval during which the collision force is non-zero.
- **PDOF** — Principal Direction of Force, taken as the direction of the peak force
- **Delta-V** — Speed change for the pulse, determined by accumulating the area under the acceleration vs. time history
- **Impulse Center** — The vehicle-fixed coordinates for the force associated with the accumulated force vs. time history

The CollisionData are used to develop a detailed 3-dimensional impulse history that may include secondary and/or multiple simultaneous impacts on the subject vehicle. At the conclusion of the simulation, the damaged vertices and acceleration data accumulated by CollisionData are used to calculate a Collision Deformation Classification (CDC) for each collision pulse on each vehicle.

The CollisionData form the backbone of DamageStudio. In fact, it is quite accurate to think of DamageStudio as a visual interface into the CollisionData. DamageStudio has the advantage of showing more information, as well as allowing the user to interact with the CollisionData and view the CollisionData as a function of time.

Damage Data Output Report

The above data are then used to produce the Damage Data output report, an example of which is shown in Figure 32-2. The Damage Data report is divided into three sections:

- Collision Kinetics
- Damage Profiles
- Crush Tables

Damage Data-SIMON, Untitled Event

--------- VEHICLE COLLISION KINETICS ----------

Vehicle Name: Acura 3.2TL 4-Dr

Imp		--- Collision Pulse --- Start	End	Length	---- Peak ---- Accel	Force	Delta-V	PDOF
No	Collision With	(sec)	(sec)	(sec)	(g)	(lb)	(mph)	(deg)
1	Buick Century 4-Dr	0.0160	0.1200	0.1040	23.80	87453	21.4	56.2
2		0.1780	0.2600	0.0820	0.91	1997	1.4	38.6

Vehicle Name: Buick Century 4-Dr

Imp		--- Collision Pulse --- Start	End	Length	---- Peak ---- Accel	Force	Delta-V	PDOF
No	Collision With	(sec)	(sec)	(sec)	(g)	(lb)	(mph)	(deg)
1	Acura 3.2TL 4-Dr	0.0165	0.1135	0.0970	29.82	87191	26.6	-37.2
2		0.1785	0.2535	0.0750	0.46	1986	0.5	-100.0

----------- VEHICLE DAMAGE PROFILES -----------

Vehicle Name: Acura 3.2TL 4-Dr

Imp		CDC	Damage Width	Width Offset	Damage Height	Height Offset	Max Crush
No	Collision With	SAEJ224b	(in)	(in)	(in)	(in)	(in)
1	Buick Century 4-Dr	02RZEW4	89.7	26.0	24.5	1.9	19.2
2		01RPEW4	17.1	-20.6	11.3	8.1	13.5

Vehicle Name: Buick Century 4-Dr

Imp		CDC	Damage Width	Width Offset	Damage Height	Height Offset	Max Crush
No	Collision With	SAEJ224b	(in)	(in)	(in)	(in)	(in)
1	Acura 3.2TL 4-Dr	11FDEW2	66.7	0.1	23.9	2.3	9.9
2		09LZEN1	10.5	46.0	13.3	7.1	0.8

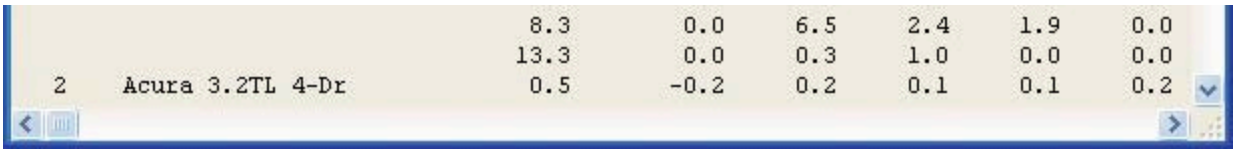
--------- VEHICLE CRUSH DEPTH TABLES ----------

Vehicle Name: Acura 3.2TL 4-Dr

Imp		Elevation	-------- Crush Depths C1	C2	C3	C4	C5
No	Collision With	(in)	(in)	(in)	(in)	(in)	(in)
1	Buick Century 4-Dr	-10.4	0.0	5.7	0.5	0.0	0.0
		-4.3	3.1	16.4	11.4	11.7	0.0
		1.9	6.9	16.8	19.2	2.4	0.0
		8.0	4.8	16.8	11.0	7.5	1.1
		12.3	1.4	15.6	11.1	6.2	0.0
2	Buick Century 4-Dr	2.5	0.0	0.4	3.1	10.1	13.5
		5.3	0.1	0.5	2.2	9.4	13.2
		8.1	0.1	0.6	2.6	7.9	12.8
		10.9	0.0	0.3	1.1	5.8	11.1
		12.3	0.0	0.1	0.9	4.4	10.2

Vehicle Name: Buick Century 4-Dr

Imp		Elevation	-------- Crush Depths C1	C2	C3	C4	C5
No	Collision With	(in)	(in)	(in)	(in)	(in)	(in)
1	Acura 3.2TL 4-Dr	-9.6	0.0	0.0	1.9	0.0	0.0
		-3.6	0.0	6.1	9.9	6.2	0.0
		2.3	0.2	4.4	0.6	1.4	0.0



		8.3	0.0	6.5	2.4	1.9	0.0
		13.3	0.0	0.3	1.0	0.0	0.0
2	Acura 3.2TL 4-Dr	0.5	-0.2	0.2	0.1	0.1	0.2

Figure 32-2: Typical Damage Data output report produced from the CollisionData.

Collision Kinetics Table

This report displays the following results for each vehicle:

- **Impulse Number** — A sequential index identifying the unique impulse
- **Collision With** — The name of the other vehicle sharing the impulse
- **Collision Pulse Start, End and Length** — The time at which the impulse begins and ends, and the duration (end time minus start time), identified by the presence of a force acting on any of the vertices included in the pulse
- **Peak Acceleration** — The highest total acceleration occurring during the pulse
- **Peak Force** — The highest total force acting on the vertices included in the pulse
- **Delta-V** — The integrated acceleration vs. time history for the pulse
- **PDOF** — The direction of the peak force occurring during the pulse

CollisionData calculates the traditional PDOF azimuth angle (i.e., the angle in the vehicle's x-y plane), as well as the zenith angle (the vertical angle). Only the azimuth angle is displayed in the table.

Because each vehicle may have up to 10 collision pulses, the Collision Kinetics table provides detailed impulse information about each collision the vehicle encounters during an event. The individual breakdown for each impulse can be extremely useful when addressing issues involving occupant exposure to injury.

Damage Profiles

This report displays the following results for each vehicle:

- **Impulse Number** — A sequential index identifying the unique impulse (same as above)
- **Collision With** — The name of the other vehicle sharing the impulse (same as above)
- **CDC** — The Collision Deformation Classification, as defined by SAE Recommended Practice J224b, for the pulse
- **Damage Width** — The width of damage, determined by the minimum and maximum coordinates of the damaged vertices along the end or side of the vehicle. For top or bottom damage, the width is in the direction of the vehicle's x axis (consistent with SAE J224b).
- **Damage Offset** — The lateral distance from the vehicle CG to the center of the damage width
- **Damage Height** — The vertical height of damage, also determined by the minimum and maximum coordinates of the damaged vertices along the end or side of the vehicle. For top or bottom damage, the height is in the direction of the vehicle's y axis (consistent with SAE J224b).
- **Height Offset** — The vertical distance from the vehicle CG to the center of the damage height
- **Maximum Crush** — The maximum vehicle actual crush depth (excluding free space), defined by the damage vertex with the greatest deformation

Note that the Damage Profile information is 3-dimensional. The 3rd character may be 'T' (top) or 'U' (undercarriage). The 5th character of the CDC describes the elevation of damage (i.e., below the beltline, under-ride, overall height, etc.). A complete CDC is generated for a rollover (actually, it will probably be a series of CDCs for the individual impulses).

Crush Depth Tables

This report displays the following results for each vehicle:

- **Impulse Number** — A sequential index identifying the unique impulse (same as above)
- **Collision With** — The name of the other vehicle sharing the impulse (same as above)
- **Elevation** — By default, the CollisionData routine divides the damage height into 4 zones, resulting in crush measurements at 5 elevations
- **Crush Depths** — By default, the CollisionData routine divides the damage width into 4 zones, resulting in 5 crush depths at each elevation (columns C1 through C10 as needed)

Crush depth is calculated by creating a vector at each crush location that is parallel to the vehicle x-y plane and perpendicular to the vehicle surface. The vector's origin is on the "shoebox" that is defined by the vehicle's overall dimensions, and is directed inward. The point of intersection with the undamaged surface geometry defines the free space for that crush location. The point of intersection with the damaged surface defines the total crush depth. The actual crush depth is the difference between the total crush depth and free space.

The CollisionData routine calculates the actual crush depth, free space and total crush depth on the impacted surface. By default, only the actual crush depth (excluding free space) is displayed in the Damage Data crush depth table.

(updated: current physics models (SIMON, EDSMAC4) provide an "Include Free Space" calculation option checkbox; when checked, the Crush Depth Tables report total crush including free space instead — the table heading indicates "Excl. Free Space" or "Incl. Free Space" accordingly.)

Continue with Using DamageStudio.

Chapter 32 (continued) — Using DamageStudio

Using DamageStudio involves the following steps:

1. Set up and execute a collision event.
2. Go to the Playback Editor.
3. Add a DamageStudio report. The DamageStudio window is displayed.

> **NOTE:** Although not required, it is a great idea to add a Damage Data report as well. Remember: it contains a synopsis of the CollisionData!

The next steps depend on the type of event (reconstruction vs. simulation) and the currently selected viewer option.

Geometry, Simulated Damage ("Simulated")

When a DamageStudio window is initially displayed,

Simulated

is the default viewer option for simulation events.

> **NOTE:** This option is not available for reconstruction events.

Because it is the default option, the *Show* checkbox is automatically checked. The viewer displays the event's first vehicle in its original condition (i.e., undamaged). The Damage Profile group information is initially blank or zero, except for the impulse number, which is *Auto*. When the impulse number is *Auto* and the user plays the simulation event, DamageStudio will automatically update the impulse number and associated damage information at the correct time as the simulation progresses.

(updated: the Auto entry in the Impulse No. dropdown is only offered for the Simulated damage view; for the other views the dropdown lists impulse numbers only.)

1. Use the Playback Controller to play the event.

When the simulation time reaches the start time for the first impulse, the impulse number changes from *Auto* to *1*, indicating that the first collision is under way. The CDC, width, offset, elevation and crush table are updated dynamically as the simulation proceeds through the first collision. The viewer displays the damage profile crush vectors and PDOF. At the conclusion of the impulse, the impulse number will return to *Auto*, the damage profile data will return to blank or zero, and the crush vectors and PDOF will disappear from the viewer.

If the event includes more than one impulse, the impulse number will change to

2

when the simulation time reaches the start time for the second impulse, and the damage profile data and viewer will display the results for the second impulse. This process continues for each impulse, as its damage profile data and viewer are displayed in sequence for each individual impulse.

The user can also select a particular impulse to review its damage profile data. To view the results for a particular impulse, perform the following steps:

1. Click on the Impulse Number dropdown list and choose an impulse number. The damage profile data for the selected impulse are displayed.

The Damage Width and Offset are not editable because they are determined directly by the simulation. However, it is possible to determine the effect of changing the number of crush zones, as well as identify crush depths at specific elevations:

1. Click on the Number of Zones dropdown list and change it from its default value, 4, to a larger number to increase the resolution of the crush measurements. There is no change to the damage profile. However, the number of rows in the crush table and number of crush vectors in the viewer reflect the additional measurements.
2. Click on the Elevation/Dist dropdown list and change the elevation/distance number from 1 to 2, 3, 4 and 5. Observe the crush table and crush vectors update as they reflect the crush depth at the selected elevation.
3. Click in the Elevation/Dist field and edit the value associated with the selected elevation/distance number. The crush table and crush vectors will change to reflect the new elevation/distance value.
4. Click *Prev* or *Next* to switch vehicles.
5. Repeat the above steps for each vehicle in the simulation.

> **NOTE:** When an impulse number is specifically selected using the Impulse No. dropdown list, the data displayed come directly from the CollisionData, which is calculated at each integration timestep. When Auto is selected and the event is played, the results are displayed directly from the output tracks, which are available at each output timestep and possibly interpolated according to the Playback Interval. Thus, there may be small differences in the results when Auto is used to replay an event vs. the explicit selection of an impulse number. Setting the Simulation Output Interval and Playback Output Interval equal to the integration timestep eliminates this difference. However, this also may greatly increase the size of the case file.

Damage, User-entered ("User-entered")

User-entered is the default viewer option for reconstruction events, and the *Show* checkbox is automatically checked. For simulation events, the *User-entered* view must be explicitly selected by checking the *Show* checkbox.

To use the

User-entered

viewer option, perform the following steps:

1. If the current event is a simulation, click the *Show* checkbox.

The viewer displays the event's first vehicle in its original condition (i.e., undamaged). The Damage Profile group information is initially blank or zero, except for the impulse number, which is

1

.

1. Enter a CDC, followed by `<Enter>` or *Apply*. The default damage profile for the CDC is displayed in the Damage Profile group and the associated damage profile is displayed in the viewer.
2. Edit the damage profile data (width, offset, elevation, crush table) and observe the changes to the vehicle damage profile in the viewer.
3. If desired, click on the Impulse No. dropdown list and select impulse number *2*.
4. Enter a CDC for the second impulse and, optionally, edit the associated damage profile data.

5. Repeat the above steps for up to 10 individual impulses (damage profiles).

The entry of user-measured damage profiles in DamageStudio parallels the Event Editor's Damage Data dialog, where a CDC also assigns a default PDOF and damage profile that may then be edited.

Geometry, Undamaged ("None")

Select *None* in the Damage dropdown and check *Show* to display the vehicle's original (undamaged) geometry. Adjust the *Transparency* slider to overlay the undamaged geometry over another view for comparison.

(updated: the original manual stated "(Not implemented)"; this view is implemented in the current release.)

Geometry, From File ("From File")

Select *From File* in the Damage dropdown, check *Show*, and use the *Filename* field / *Open...* button to load a user-supplied geometry file (for example, a scanned or independently modeled damaged vehicle) into the viewer for comparison.

(updated: the original manual stated "(Not implemented)"; this view is implemented in the current release.)

Damage Photograph ("Photograph(s)")

> **NOTE:** This viewer option is **not available**. *Photograph(s)* is not offered in the Damage dropdown and cannot be selected. See Chapter 1 — Damage Photograph.

Some Notes About Damage Profiles

The general nature of quantifying and measuring an irregular damage profile leads to some interesting observations. The notes below are intended to help the user understand and interpret their results.

- Each damage profile has a single CDC describing the entire damage pattern. Therefore, a damage profile has a single width and width offset. The damage width does not vary according to elevation. In addition, a damage profile has a single height and height offset.
- It is likely that the crush depth will be zero at numerous points within the damage profile. These points typically occur above or below the elevation associated with the maximum damage width (where the damage width is, in fact, defined).
- It is not uncommon for the total crush depth at the endpoints of damage to be very large. This occurs because the vehicle is not truly rectangular. The vast majority of this damage (perhaps all of it) is free space. This can also occur at the top and/or bottom elevations (for the same reason).
- Anomalous crush depth values may occur for obscure reasons. For example: During a frontal collision the fender flares are crushed inward. As a result, the crush depth at that point on the profile is measured to the rear of the (undamaged) fender well, resulting in a very large crush depth. It is not free space, because free space is determined by the original (undamaged) vehicle shape, so the fender flare is the surface used for the free space calculation.
- If a vehicle geometry has gaps, the crush vectors can be very large, simply because the arrow never contacted the surface until it reached the other side of the vehicle. This often occurs as a result of surfaces with reversed surface

normals.

> **NOTE:** See the Crush Depth Tables discussion in Chapter 32, part 1 for more information about the procedure for calculating crush depth and free space.